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PATENT

Sub-Spec

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TO ALL WHOM IT MAY CONCERN:

Be it known that I, WERNER AGNE, a citizen of Germany, whose post office address is Himmelgarten 21, 90552 Röthenbach, Germany, have invented an improvement in

METHOD AND APPARATUS FOR PREVENTING DAMAGE TO MACHINE TOOLS, PRODUCTION MACHINES AND ROBOTS

of which the following is a

SUBSTITUTE SPECIFICATION

FIELD OF THE INVENTION

[0001] The invention relates to a method and apparatus for preventing damage to machines such as machine tools, production machines, and robots resulting from power supply faults.

BACKGROUND OF THE INVENTION

[0002] EP 0 687 395 B1 discloses a method of preventing damage to numerically controlled machines in the event of a power failure. According to that disclosure, in the event of a power failure, the supply voltage for at least one axis drive motor is obtained

from the kinetic energy of at least one other axis drive motor, with the result that a position-controlled, programmed emergency return traverse takes place.

[0003] EP 0 583 487 B1 discloses a method of braking the axis drives of numerically controlled machines optimally in terms of time and without deviation of the tools from their paths. In these machines, emergency braking of the axis drives is provided for in hazardous situations. If emergency braking is triggered, the drives of the numerically controlled machine brake linearly in the shortest time with the nominal rotational speed values being correspondingly prescribed. The intent of such time-optimal, path-maintaining braking is to avoid collision of the tool with the workpiece or other objects that would otherwise occur from deviation of the tool from its intended path.

[0004] A rotary printing machine is described in WO 97/11848. Such a machine generally comprises a plurality of rotary presses which can operate simultaneously and independently of one another. Each rotary press comprises, *inter alia*, roll carriers for the paper rolls, draw rollers for drawing the paper web in and out at the printing towers, printing stations, which operate in combination as U, Y or H printing units in one or more printing towers, auxiliary drives at the printing stations and a folder.

[0005] If a failure occurs in the power supply to machines, such as machine tools, production machines, and robots, unforeseeable machine states may occur until the system is brought to a standstill. These machine states may damage a product being processed and also damage the machine itself. Under certain circumstances, such damage

may result in costly repairs, long shutdowns of the machine, and lost time expended on resetting the machine for a controlled production start-up.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is to provide a method and apparatus for monitoring the required quality of power from a power supply system for a machine in order to sense unwanted power supply states in real time, and for initiating a drive braking function which brings about a machine standstill with minimal or no damage. According to the present invention, this object is achieved by:

- monitoring with a system monitor an electrical power supply system for the presence and maintenance of a required quality of power;
- transmitting an indication of an unwanted power supply system state in real time to a drive controller for the machine with master functionality; and
- initiating a machine drive braking function and/or effecting a machine standstill.

[0007] The real-time transmission of a faulty power supply state means that the control system for the machine is prepared to effect a machine standstill from the time the fault is detected. The drive controllers for the motors of the machine usually have an energy store, so that an unwanted power supply state does not have immediate effects on the machine functionality. Even before this energy store has been depleted, the machine can

be brought to a standstill. Since this takes place in a controlled manner, i.e. the machine standstill is completed in a time period in which the machine is still supplied with power, machine and product defects can be kept to a minimum or avoided completely. As a consequence, extremely short machine downtimes can be achieved, provided that a power supply is readily available. Consequently, any financial loss would be low, since damage and downtime are minimized.

[0008] In a preferred method of the present invention at least two individual drives can be synchronized with one another and a synchronized drive braking function (and/or a machine standstill) is initiated by detection of an unwanted power supply system state. By this method, uncontrolled idling of drives which can be synchronized with one another is avoided. In particular, if individual drives operate in a way in which they are synchronized with one another, it is also necessary, if so required, to bring them to a standstill in a controlled manner to avoid damage to machines and products.

[0009] In a further preferred method of the present invention a real-time Ethernet is used for the transmission of an unwanted power supply system state. Consequently, the methods according to the invention can be employed using a universal and standardized bus protocol with a high transmission capacity.

[0010] In yet a further preferred method of the present invention, an unwanted power supply system state is transmitted in real time to a drive controller with master functionality in one drive group of a machine having multiple drive groups and this information is provided to other drive groups via a real-time cross communication. By

this method it is ensured that when a power supply fault is transmitted from the power supply system monitor to only one drive controller with master functionality, other drive groups are also notified of the forthcoming event in real time. A synchronized drive braking function and/or a synchronized machine standstill can also be brought about via the real-time cross communication.

[0011] An advantageous application of the present invention is obtained in a machine tool, or production machine, or robot having at least two synchronizable individual drives of rotating machine elements and at least one real-time data communication system.

[0012] A further advantageous application of the invention is obtained in a printing machine with at least two synchronizable individual drives of rotating machine elements and at least one real-time data communication system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A preferred embodiment of the present invention is described in more detail below and in conjunction with the appended drawing, in which:

The single Figure shows a block diagram of interlinked drives for a machine, which are connected to a common power supply system including a system monitor.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In the drawing Figure, each of the major components A1 to A6 of a drive arrangement for a machine is depicted in a rectangle with a broken outline. Each of the

drive components A1 to A6 comprises at least one motor M1 to M6, which is activated by a respective drive controller AR1 to AR6 by power electronic circuits LE1 to LE6. The latter are indicated with a symbol conventional in power electronics, namely the IGBT circuit symbol. As illustrated, the drive components A1 to A6 are divided into two groups, A1 to A3 forming the group AG1 and A4 to A6 forming the group AG2, each of the groups being shown within broken line rectangles.

[0015] The three drive controllers AR1-AR3 and AR4-AR6 of respective drive groups AG1, AG2 are interlinked with one another in the form of a ring. Further networking structures, feasible in terms of data technology, may also be provided for the drive controllers AR1 to AR6. In each case, one drive controller, AR1 of drive group AG1 and AR4 of drive group AG2 has master functionality. This is identified by the letter M. The data network AB1, AB2 close to the drive undertakes the synchronization of the drives in each of the drive groups AG1, AG2, respectively. A cross communication link Q makes it possible for the drive controllers with master functionality AR1, AR4 to exchange data close to the drive, which are necessary for the mutual coordination of open-loop or closed-loop control actions.

[0016] For each of the drive controllers with master functionality, AR1, AR4, there is a respective master computer L1, L2, which performs a function with higher-level control over the drives. The master computers L1, L2 are connected to each other via master computer bus LB and can, for example, collect, exchange, evaluate and display process data to provide a human-machine interface. All the data connections Q, LB, AB1, AB2,

NS can, if so required, be executed by a real-time data network, such as a real-time Ethernet.

[0017] The power electronics LE1 to LE6 of the drives A1 to A6 are connected to the power supply system V via power distributor network EV and power supply system monitor N. In this case, system monitor N senses the presence and maintenance of required limits for power quality. If a system failure of the power supply system V occurs, or if the required quality of power is not maintained, a signal is transmitted to the drive controllers with master functionality AR1, AR4. If a rapid response to this state is required, a real-time data link is preferable.

[0018] Information from the system monitor N can be made available to various components of the drives, and also higher-level institutions. Various data link configurations are conceivable, such as a serial, an annular or a star-shaped link structure.

[0019] In illustrated arrangement, the system signal from monitor N is made available on link NS to the drive controller with master functionality AR4. An optional link to the master computer L2 is depicted by broken lines. The drive controller with master functionality AR4 can notify the other drive group AG1 of this information with the aid of the cross communication link Q.

[0020] If an unwanted system state occurs, all the drives A1 to A6 can immediately initiate a drive braking function and/or a machine standstill, which may be synchronized by a drive controller with master functionality, either AR1 or AR4. (AR4, in the example shown.) The synchronization of the drives AR1 to AR6 during a drive braking function

avoids or minimizes damage to the product, and also to parts of the machine itself. If, for example, a printing machine is brought to a system standstill on the basis of information from the system monitor N, the synchronization of the drives A1 to A6 ensures that a transported paper web does not tear. System damage due to a torn paper web is also avoided, for example, jamming of machine parts caused by bits of paper. The overall benefit that results is that the downtime of the printing machine can be significantly reduced.

[0021] If major data lines are equipped with real-time functionality, immediate response is possible and the information occurring in the course of a braking function can be made available throughout the machine drive control arrangement in real time. Even before the stored energy from the converters LE1 to LE6 of the drives A1 to A6 is used up, a machine standstill can be brought about.

[0022] The use of a real-time Ethernet having at least one data link Q, LB, AB1, AB2, NS means that a standardized, widespread and universally usable bus protocol is used. This makes short bus cycles possible by its high transmission capacity. Consequently, system data which require a fast response, such as a correction of deviations from nominal values, can be advantageously made available in real time.

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